E-VOTING READINESS MAPPING FOR GENERAL ELECTION IMPLEMENTATION

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ABSTRACT

General elections are a common thing in the world for democratic countries to elect their leaders and deputies in parliament. Today's technology offers an electronic-based electoral system called e-voting, a safer, faster and more efficient system. Due to privacy, verification and confidentiality of conventional elections, there are many countries, both developing countries and developed countries around the world, that have implemented e-voting, such as: India, Brazil, the Philippines, Argentina, United States, Belgium, Canada, Japan, Mexico, France, Peru, Australia, Costa Rica, Finland, Guatemala, United Kingdom, Ireland, Italy, Kazakhstan, Netherland, Germany, Paraguay, Norway, Switzerland and others. Of those countries, there are countries which are successful and sustainable, unsuccessful or canceled the program due to many problems, only limited the program to trial and not continued, or only limited the program to partial implementation. This research presents a mapping of the elements needed to deal with the implementation of e-voting by referring to the successful and unsuccessful countries in its implementation, as well as to the previous e-voting research. There are two contributions produced in this research. First, mapping the preparatory components in building the e-voting ecosystem. Second, the mapping of these components can be used as the basis for creating an e-voting framework. Hopefully the results of this research can give contribution to countries or organizations that will carry out e-voting or research of develop e-voting framework in the future.

Keywords: *E-Voting, Election, Technology, Mapping, Framework*

1. INTRODUCTION

Elections are a prevalent activity in the world for democratic countries to elect leaders or parliament representatives in their countries[1], at this time, technology can apply in all activities including elections, e-voting is technology used to assist election activities using electronic media [2], elections that commonly used paper ballot that is pierced or crossed out replaced with digital ballot that does not need to be printed [3], voters only choose on a computer screen then the committee counts automatically so that more fast and efficient [4] and minimalized malpractices in election, of course, future-oriented countries will switch to e-voting [5] because of Privacy, verification, and "[6], many states have implemented e-voting such as India, Brazil, the Philippines, Brazil, Argentina,

United States, Belgium, Canada, Japan. Mexico, France, Peru, Australia, Costa Rica, Finland, Guatemala, United Kingdom, Ireland, Italy, Kazakhstan, Netherland, Germany, Paraguay, Norway, Switzerland and many more [7][8][9], but the fact is the use of technology e-voting in general elections in these countries does not run smoothly, some are successful and sustainable, canceled for various reasons or only partially implemented at the urban or rural level.

Only four countries are successful and sustainable in the implementation of e-voting, such as India, Brazil, the Philippines, and Estonia, even though e-voting technology has been developed for more than 30 years [10], of course, most are not successful because of several things, below are presented Countries that implemented e-voting

along with its implementation status collected from various sources[11] :

Table 1: E-voting implementation

No.	Status	Country
1	Countries that have implemented e-voting completely	India, Brazil, the Philippines, and Estonia
2.	Countries that have implemented e-voting partially	Argentina, United States, Belgium, Canada, Japan. Mexico, France, and Peru
3	Countries that canceled the implementation after conducting tryouts of e-voting	Australia, Costa Rica, Finland, Guatemala, United Kingdom, Ireland, Italia, Kazakhstan, and Norwegian
4	Countries that did not continue the implementation of e-voting	Netherland, Germany, and Paraguay
5	Countries that are in the process of Testing e-voting	Bangladesh, Bhutan, Ecuador, Mongolia, Switzerland, Nepal and Indonesia

From the table above, it raises many questions, why are only a few countries successful and sustainable? Why do developed countries withdraw from e-voting and fail? Why are they successful?, In this research, successful and unsuccessful countries are collect to get information. From the information collected, compared with the existing studies on e-voting, this paper drew conclusions to contribute to the progress of e-voting, and of course made contribution for countries that will implement e-voting in their general elections.

2. RESEARCH METHOD

This study was using the literature review method with reference to the review method promoted by Webster [12], and using the key search:
   1. "e-voting"
   2. "e-voting technology"
   3. "e-voting in various countries"
Furthermore, to enrich the results of the research in this paper and in accordance with the intention of the authors to contribute to the implementation of e-voting on a wide scale, we reproduce the literature with key searches including:
   1. "e-voting framework"
   2. "socio-technical research"
In searching literature based on the above criteria, we only use data between 2017 and 2020 in several databases including google scholar, IEEEXplorer, Science Direct, Proquest etc. The results of subsequent searches are obtained with the following phases:
1. Filter all the literature obtained by minimizing the scope that is e-voting implemented in various countries
2. The table-based to the State by stating the time of implementation, the technology used and the status of its success
3. Filter the table with a selection of successful and unsuccessful countries
4. Make critical point table
5. Make e-voting readiness mapping
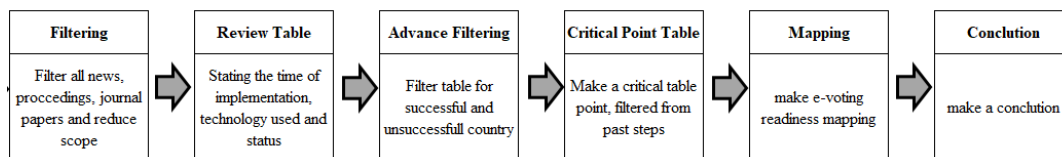6. Make a conclusion

These phases described below:

Figure 1: Research Phase

3. LITERATURE REVIEW
Electronic voting or e-voting is an election activity with the support of technology. The voting is not done by punching a hole in the paper, but the voters vote by machine, and the ballots are stored in digital form [2]. E-voting is an election activity in which the recording and the counting of votes are carried out using electronic media [3]. Electronic

voting machines were intended to reduce errors and speed up the counting process. The advantages of e-voting over conventional systems or ballots according to [2] and [12] are:

1. Eliminating the possibility of invalid and questionable votes, which in many cases are the causes of controversy in elections.
2. Making the vote counting process much faster and more accurate than conventional systems.
3. Reducing the amount of paper used is environmentally friendly
4. Reducing printing, distribution and committee costs

The following are some of the countries that have, or have been and are continuing to implement e-voting, which are presented in two parts: Successful Countries and Unsuccessful Countries.

3.1 Successful Countries

3.1.1. India

India is the largest democratic country in the world, which began the experiment of the use of e-voting for its 16 states in 1989-1990 in Madhya Pradesh, Rajasthan and the Capital of Delhi. The e-voting pilot project in India actually has been started since 1982 on a limited basis [13], but the Assembly in the State of Kerala canceled it, because it was not in accordance with the law. However, later on, India changed the state law that arrange and ratified the election using e-voting technology. Therefore, since 2003 in India, all states have already used e-voting technology for elections. In 2014, the voters in India were registered as 814 million and there were 930 thousand polling stations using Electronic Voting Machines (EVM). Initially, the e-voting machine in India consisted of two units, namely the voting machine and the control unit. The voting machine is stored in the voting booth and the control unit is kept within the authority of the voting officer. However, started from the 2014 elections, the voting machine has been added by the existence of a VVPAT (Voter Verifiable Paper Audit Trail) machine, in which this machine has the function to print the ballot papers chosen by the voters which can be counted manually if desired. All of the e-voting

equipment do not depend on electricity supply, internet, WIFI or USB) [13].

3.1.2. Brazil

Brazil conducted e-voting after conducting a feasibility study, and the Brazilian Supreme Court passed a law on the use of e-voting technology in 2000, the Brazilian election committee began partial implementation in 2006 in the city of Santa Catharina, in the first implementation, Brazil succeeded in installing 400,000 machines in the form of kiosks in crowded centers, Brazilian e-voting machines in the form of touch screens and integrated keyboards, from the beginning brazil used the VVPAT engine for audits and during the implementation didn't get any significant problems [2][14].

3.1.3. Philippines

The Philippines began implementing e-voting in 2010 after the Philippines electoral commission (COMELEC) issued instructions using e-voting in general elections, Philippines used a machine called PCOS where the voters were given a special ballot by the election committee and marked it after the ballot finished taken to a machine like OMR (Optical Mark Recognition) whose function is to scan ballot papers, the calculation process is carried out in stages automatically from the village, the province to the tabulation center and the election results using e-voting in the Philippines were ratified, despite many conflicts.

3.1.4. Estonia

The e-voting pilot project in Estonia began in 2003, and in 2007 after the Estonian parliament approved the general election using e-voting, its implementation began, Estonia was the first country to implement e-voting using the internet, the general election process by which each voter had to register one phone number to the general election commission as an identity, during the electoral process, voters in front of an internet-connected computer and mobile phone as a verification medium [15][16].

By the information presented in the literature above, we made the following table:

Table 2. Comparison e-voting technology

Countries → Technology ↓	India	Brazil	Philippines	Estonia
Hardware	EVM (Electronic Voting Machine)	GX-1 Integrated Processor	PCOS	None / Gadget voters /internet voting
Paper Audit Trail	VVPAT Machine	VVPAT Machine	Yes (conventional ballot)	Yes (Digital Receipt)
Internet connection	None	None	Yes (only for counting)	Yes
Wi-Fi / USB	None	None	Yes (only for counting)	Yes
Power	Battery	battery	Battery and electric	Battery and electric
Result	Success, No problem	Success, No problem	Success but many negative comments / claims from the public	Success but many negative comments / claims from the public

3.2. Unsuccessful Country

3.2.1. Netherland

The Netherlands began to study the implementation of e-voting since 1965, the e-voting system developed by two local Dutch companies, first used in 1980, in 2004, began to launch e-voting through internet connections including residents who were abroad. Still, In 2006, anti-e-voting rejection began to emerge from the public, issues that arose were security and distrust of the e-voting system so that in 2007 the Netherlands revoked the certification of e-voting devices. From then on, e-voting was discontinued [17].

3.2.2. United Kingdom

The United Kingdom uses DRE (direct-recording electronic voting systems) equipment for general elections, the device made by a local company which used in 2003. But, according to the survey, it didn't have a significant impact on increasing the number of voters especially the rejection of digital rights advocacy groups that observed and tested used e-voting device, they argue that the implementation of e-voting cannot be trusted, the UK decided to return to conventional elections starting in 2009 after the parliament voted in 2007 [18].

3.2.3. United States

The United States began implemented e-voting in 2004 although the e-voting pilot project had begun in 1990, in its implementation, it was carried out in a blended manner in 3 ways namely conventional, semi-conventional where voters after marking ballots, scanned by officers and with DRE machines (direct-recording electronic voting systems) commonly used in e-voting [19], but in reality, e-voting has always been a controversy in the country [18], people prefer the conventional way, namely the first way, in the 2016 elections, almost 70% of voters in the United States chosen conventionally, and finally, in the 2018 election, America returned to conventional in the system election.

3.2.4. Germany

In 2009 Germany released a legal product related to transparency of public data relating to e-voting where each voter must be able to verify the results of his choice and cannot be opened by others even though by specialized experts, this legal product arises because of public concerns about data security. Still, no system complied with these legal products, and finally, Germany banned e-voting devices from being used in elections [7].

3.2.5. Norway

Norway is open in the implementation of e-voting, before its implementation, the Norwegian election commission opens to the public the program code and cryptography, system made by Spanish companies, the e-voting process in Norway is carried out by voters getting letters sent by post containing verification code and candidate list, e-voting server sends an SMS to match the verification code then voters can vote through their personal computers. But, many Norwegian publics are worried about the security of the e-voting system because there are facts in 2013, voters can vote for more than once, and finally, the Norwegian government after speaking with parliament, the e-voting process in the country has ended [8][20].

Presented in Table 3 below, are countries that have not been successful in implementing e-voting with the problems they face.

Table 3: countries with problem

No	Countries	Problem
1	Netherlands	1. Public mistrust of e-voting 2. Public distrust of e-voting devices
2	United Kingdom	1. The British government considers that the e-voting device used is not secure and does not guarantee the secrecy of the voters 2. Digital rights advocacy groups that observe e-voting testing show that e-voting implementation can't be trusted
3	United States	1. Almost 70% of voters in united states voted in conventional, it was considered no significant effect 2. There was controversy in the e-voting system secure
4	Germany	1. Government concerns about the security of e-voting devices 2. E-voting device vendors cannot comply with the e-voting device security standard requirements
5	Norway	1. Many people worried about the security of e-voting systems 2. There are facts in 2013, voters can vote more than once

4. DISCUSSION

In countries that are successful in implementing e-voting, can be concluded are
1. Only Countries that use microcomputer devices without an internet connection that successfully seamlessly implemented e-voting,
2. Countries that use internet connections successfully implemented e-voting but are not smooth, many negative comments and concerns from the people of these countries, especially privacy, verification, and confidentiality,
3. Most developing countries have successfully implemented e-voting
4. All countries that successfully implemented e-voting began the trial, feasibility studies, and had a strong legal.

Whereas in unsuccessful countries it can be concluded that:

1. Public concern plays an essential role in the failure of e-voting implementation in a country,
2. Public trust in e-voting is essential for the implementation of e-voting in the future
3. The security of e-voting systems is a matter that is controverted by the public
4. There is only a little fact that e-voting is not secure, people's concerns are more dominant than facts

Learning from the experiences of the countries that were success, unsuccessful or canceled the implementation of e-voting, we compiled studies about e-voting particularly about essential things that need to be prepared to implement e-voting, summarized in a table with the following details by adopting the structure of a table by Jane Webster and Richard T. Watson [21][11].

Table 2: Article summarized

No.	Concept	Article						
		[18]	[22]	[6]	[23]	[24]	[16]	[25]
1	Public trust toward the government		x	x	x		x	
2	Public trust toward election organizer			x	x	x	x	
3	Public trust toward technology/e-voting	x	x	x	x		x	x
4	ICT infrastructure readiness				x		x	x
5	Human resources		x	x				
6	Legislation readiness							x
7	Election organizer readiness	x			x			
8	Technology/e-voting readiness	x			x	x	x	x
9	Security					x	x	

4.1. E-Voting Element Mapping
From table 1 above, it can be concluded that there are four main factors that influence the successful implementation of e-voting. All of them influence each other, with a picture like the one below which can later be developed into an e-voting implementation framework [26].
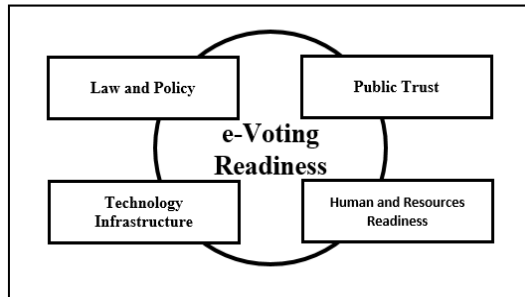
Figure 2: e-voting readiness mapping

4.1.1. Law and Policy
Law and policy is one sector that plays an important role in the implementation of e-voting. Some successful countries initially had problems with law and policy. Like India, which started implementing e-voting in 1982 partially, but the parliament canceled it because it was not in accordance with the law. However, in 1989, the Indian parliament improved its laws so that in 2003, e-voting in India was carried out more broadly by implementing it in its sixteen states without laws and lawsuit [13]. Likewise with Brazil, which implemented e-voting in 2006 after revising the law in 2000 [2]. Thus, the legal products and policies regarding the implementation of e-voting need to be prepared. The parliament and the government need to prepare or revise laws before their implementation.
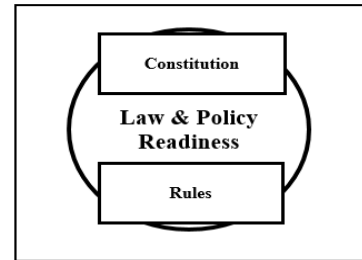

Figure 3: *Law & policy mapping*

4.1.2. Public Trust
The public trust upon the implementation of e-voting is an important sector in the implementation of e-voting. Most of the countries that failed in the implementation of e-voting, proved that the role of public trust is very dominant. The Netherlands canceled the implementation of e-voting because the public did not believe in the security of its technology [17]. The United Kingdom, after implementing e-voting in 2003, finally in 2007, the parliament decided to return to the general elections conventionally because of many public rejections about the security of the data generated. In the United States e-voting has always been a controversy in that country [19]. People prefer the conventional way, the first method. In the 2016 elections, nearly 70% of voters in America voted conventionally, and finally in the 2018 elections, Americans returned to conventional voting systems. Likewise with other countries, public trust is one factor that triggers failure in the implementation of e-voting. Public trust in the implementation of e-voting, collected from several sources [6] [16][18][22][23][24] . can be mapped with the following description:
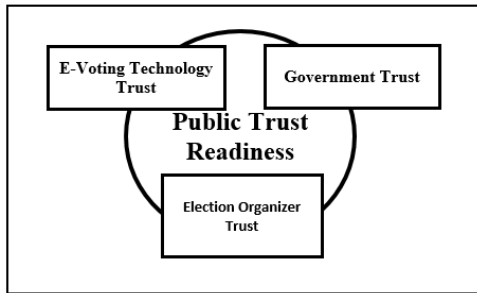
Figure 4: Public trust mapping

4.1.3. Technology Infrastructure

The readiness of e-voting technology infrastructure plays an important role in e-voting implementation. Technology is a major factor to the successful and unsuccessful countries in its implementation. India, Brazil, the Philippines, and Estonia [13][14][16] are countries that have successfully applied their technology to the entire parts of the country and provide a sense of security and trust in the community. While the Netherlands, United Kingdom, Germany, United States, Norway and others, are examples of countries that have failed due to technological factors [7][8][17][19][20], Public trust and readiness of hardware, software, data transmission and all infrastructure security are things that are considered important [16][18][23][24][25], and they can be mapped as follows:
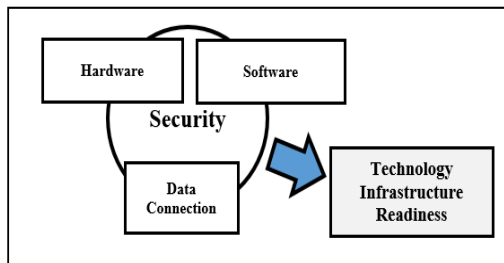

Figure 5: Technology Infrastructure mapping

4.1.4. Human Resource Readiness

Human resources is one of the factors that plays an important role in the successful implementation of e-voting [6][22]. Particularly, the elements of human resources in question include:

1. Human resources of the information technology experts
2. Human Resources of the e-voting committee
3. Human resources of the voting rights holders (voters)

Those three elements of human resources must be prepared in changing the general election from conventional to electronic, and its implementation. They can be illustrated in the mapping below:
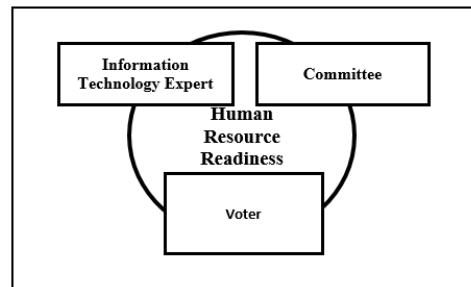

Figure 6: Human Resource Mapping

4.2. Element Interdependent

The preparation of the important elements above cannot be prepared partially. The four elements are interdependent, some of the activities carried out across elements, they can be illustrated in the figure below
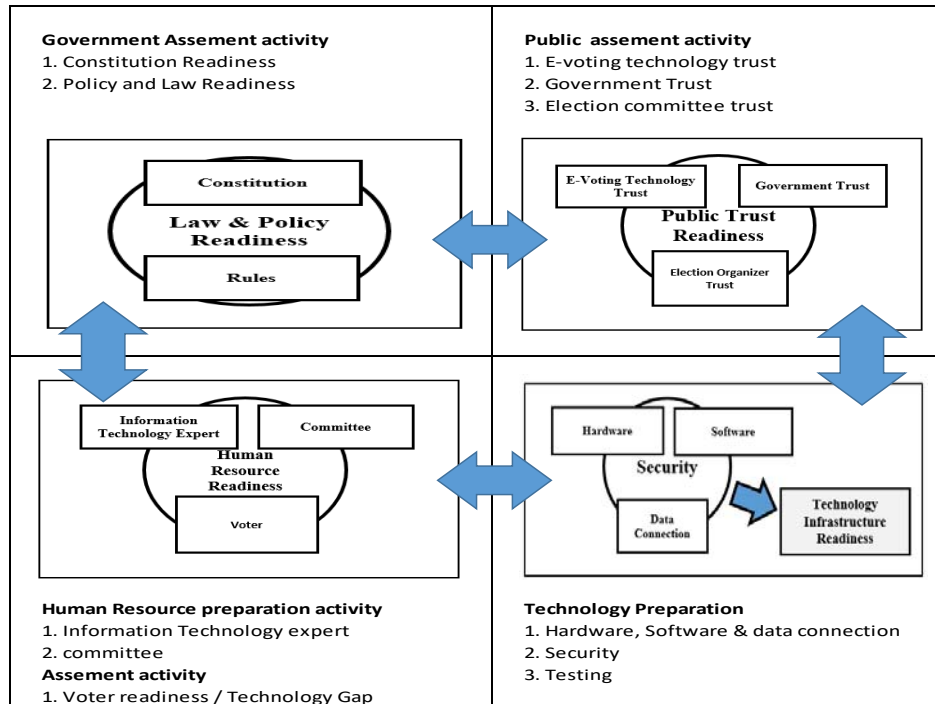
Figure 7. Elements interdependent

From the interdependent elements described above in Figure 7, priority scales and structured steps are then made to prepare for the implementation of e-voting on a broad scale or general election. These steps include:

Step 1: Public assessment and government assessment comprising of:

1. Trust to government, is the study of how far public trust the government
2. Trust to technology, is the study of the extent to which public trust technology particularly e-voting technology.
3. Trust to election committee, is the study of the extent to which public trust the general election committee
4. Technology gap, is the study of the extent to which the gap of technology users in the society.
5. Policy readiness, is the study of the extent to which the country's constitution or law support the implementation of e-voting
6. Human resources readiness, is the study of the readiness of human resources in implementing e-voting
7. Infrastructure readiness is the study of the extent of infrastructure readiness in the implementation of -voting

Step 2 : Mapping of User Requirement and E-voting Procedure

1. User requirement mapping, is a mapping study about e-voting technology on the user's side. This needs to be conducted so that e-voting technology can be used by all levels of society.
2. Procedure requirement mapping, is a mapping study of planned procedures for implementing e-voting
3. Technology mapping, is a mapping in the field of technology. This is conducted to find out what kind of technology is suitable to be applied in a country. This study is the continuation of the two previous requirements.

User requirements and procedure requirements document is a document to prepare to make a system and technology model used in the implementation of e-voting, resulting from the technology assessment gap and policy and law assertion activities. *User requirements* are terms that are usually used in information system modeling. *User requirements* documents are generated from the analysis of the current system or existing procedures. In the implementation of e-voting, these documents are not only in the form of results of the current system analyst and procedures, but a results of assessment activities such as to the public, government, policy and law.

Step 3: Socio technical research, is the study to make e-voting technology models and interrelated with people's behaviors, culture, and social, research to create mutual engagement between social behavior and technology to form a unity between users and proposed e-voting technology [27] [28] so that technology can be accepted by the public. In general, the failure of the implementation of a technology is because the makers only prioritize the technology side, and do not think about the social elements of users such as habits and culture. Especially in the implementation of e-voting, many countries fail because people are pessimistic about the technology used or the technology is not appropriate to be used in the country. Socio-technical research produces e-voting technology recommendations that are appropriate and comfortable to use by the community so that in the implementation of e-voting results in an increase in the number of voters and public trust.

Step 4: Technology modeling, Design, prototyping, simulation and testing, are mapping activities of physical needs of technology both software, hardware and communication data scheme. All processes in this stage are strongly influenced by all of the previous stages. The technology designed is influenced by technology requirement mapping that has gone through socio-technical research.

The picture below is a description of the steps that must be taken before the implementation of e-voting is carried out, so that the implementation does not get a significant problem.
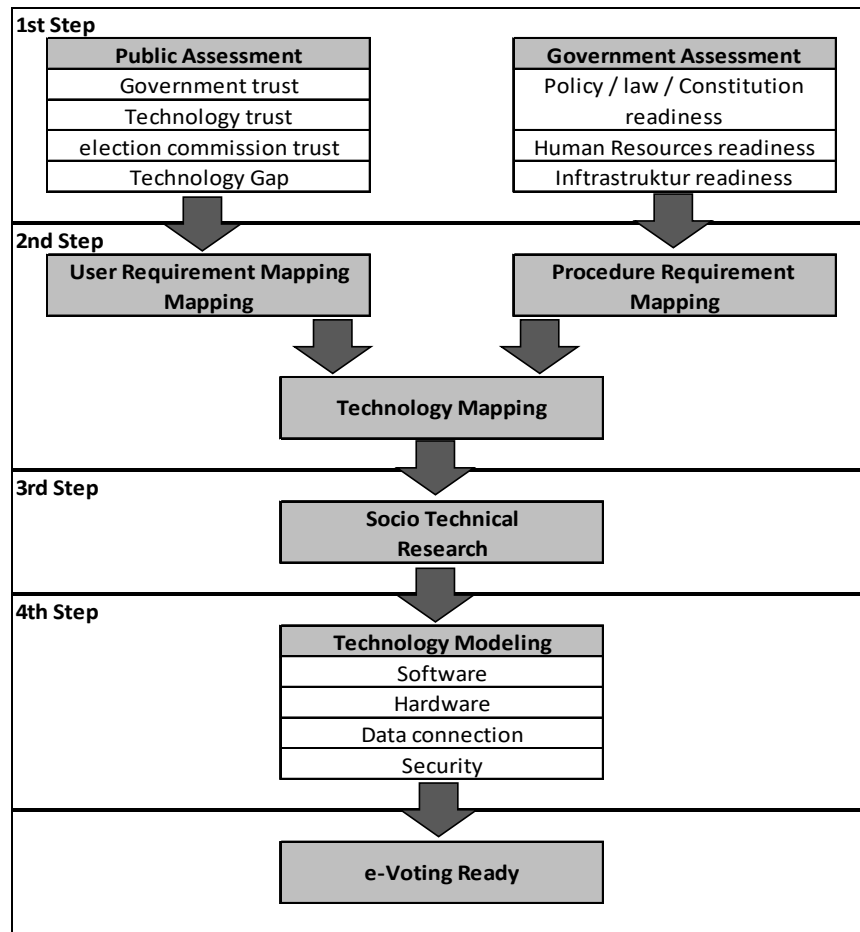

Figure 8. E-Voting Preparation steps

5. CONCLUSION

The success of a country in the implementation of e-voting is not only due to the technological reliability. And vice versa, the failure of it is not only due to the technological unreliable. There are many factors play the roles. As it is shown in the readiness mapping above, the factors of policy and legal readiness, public trust,

technological readiness and human resource readiness contribute to the successful implementation of e-voting [11][27]. There are two contributions produced in this research. First, mapping the preparatory components in building the e-voting ecosystem. Second, the mapping of these components can be used as the basis for creating an e-voting framework.

Every country needs a framework in the implementation of e-voting so that the implementation is planned and well-organized [5][25][26][28][29],There has been a lot of researches on the framework for implementing e-voting, but it is partially limited to the needs of certain countries, Future studies are suggested to design a general framework that can be used in countries around the world that will implement e-voting, so that its implementation runs smoothly.

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